COMMENT

An alternate method of calculating the population density of monsters in Loch Ness

We have arrived at biomass estimates for the Loch Ness monster that are similar to those provided by Sheldon and Kerr (1972), but we have used a different method of calculation. A description of our method follows.

Sheldon et al.(1972) reported that the standing stock of oceanic organisms in ecologically stable areas is relatively independent of individual size when measured over logarithmic size intervals. We assume that this relationship is also valid for large lakes. If so, the size-density relationship for oligotrophic Loch Ness might closely resemble observations for marine areas of low productivity. We used the method of least squares to fit a power function to equatorial Pacific data provided by Sheldon et al. (1972). From this, we estimate that particles of the order of 1 m in diameter will occur at a concentration of 0.0019 ppm.

From data set out by Hutchinson (1957) we estimate the volume of Loch Ness as the product of a mean depth and surface area (57×10^6 m^3 $\times$ 132 m $= 7.52 \times 10^9$ m^3). Accordingly, the total standing stock of monsters is calculated as $0.0019 \times 7.52 \times 10^9/10^6 = 14.3$ m^3 of monster. Each cubic meter of monster might reasonably correspond to 1,100 kg, indicating a biomass of 15,725 kg; this estimate is very close to the 15,675 kg calculated by Sheldon and Kerr (1972) as an upper limit. It follows that our population estimates also agree. The population might range between 157 small monsters (100 kg) and 10 large monsters (1,500 kg).

Our estimates are derived primarily from data for the equatorial Pacific, none other being available. This assumes that the two areas are comparable; it is known that both exhibit low productivity. We note that the abscissa of the particle size /concentration graph we used is logarithmic, so that reasonable changes in our initial choice of monster size will have little effect on the ensuing calculations. We therefore conclude that we are in agreement with Sheldon and Kerr and put these estimates forward as a further contribution to the study of an organism that is at best difficult to observe.

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REFERENCES

Hutchinson, G. E. 1957. A treatise on limnology, v. 1. Wiley.

Sheldon, R. W., and S. R. Kerr. 1972. The population density of monsters in Loch Ness. Limnol. Oceanogr. **17**: 796–798.

———, A. Prakash, and W. H. Sutcliffe, Jr. 1972. The size distribution of particles in the ocean. Limnol. Oceanogr. **17**: 327–340.

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The Loch Ness monster—limnology or paralimnology?

Now that the discussion of the Loch Ness monster, fact or myth, has been elevated to the learned columns of this journal (Sheldon and Kerr 1972; Scheider and Wallis 1973), I hope limnologists will feel less inhibited professionally in debating, at least in a semiserious vein, whether the monster belongs to their science or to para-

science. As a declared skeptic, I welcome demonstration by Sheldon and Kerr of a *possibility* as a contribution to that debate, but feel they do their case a disservice by drawing conclusions from weakly-based assertions. Using *N* for "Nessie"—a name beloved of the news media when solid news is sparse—the following table, with key words underlined, summarizes the argument.

Assertions	*Conclusions*
N "rarely seen," but by "direct observation" known to be large.	*N* therefore small in number.
Because "corpses are never found" and "small monsters are not common."	"Loch Ness must contain a small number of large *N*."
"Observational data"	"agree(s) well" with an *N* length of 8 m.
N has been "seen in the loch for hundreds of years."	There must be a breeding population.
N is "never caught."	But to suggest that *N* does not exist is "irresponsible and illogical."
Skeptics are "at fault."	*N*-observers "should be encouraged."

A fish-eating economy does appear to be the only possible one for *N* in the impoverished, dark, peaty waters of Loch Ness. The logical approach, which perhaps the authors intended, would start with: "Let us *assume* that what has been 'seen' is *N*, and then calculate whether *N*-existence is *possible* on nutritional grounds" (and on energetic grounds related to chase and capture—although migrating salmon pass through the Loch for part of the year, no salmon-chasing commotions have been reported, as far as I know). But this still leaves the principal question—what has been "seen" and "observed"?—unanswered. A professional view on the subject is that of Burton (1961). Formerly a zoologist in the British Museum, Burton was later the science correspondent of *London Illustrated News*. He gives a number of possible explanations—some of them more plausible than others—for what has been seen, but concludes that "there seems to be no evidence at all for the existence in Loch Ness of plesiosaurs or any other prehistoric monster" (Burton 1961, p. 172).

If Sheldon and Kerr's arguments are sound, they apply with equal force to other large lakes with relatively stable biotic compositions and fish faunas. Why in all these lakes, and in Loch Ness for that matter, has no tooth or scale, no bone or skin, no tangible trace come to light over the centuries? There are "monsters" in the deep oceans, but proof of their existence is based, not on an unsupported assertion, but on tangible zoological evidence. For even the Leviathan is sometimes stranded; and tentacles of giant squid occasionally surface as evidence of mortal battles with sperm whales. There remain many mysteries in the ocean, but they are based on real clues, on tangible specimens or artifacts: for example, Schmidt's giant *Leptocephalus* in the Copenhagen Museum. In Loch Ness, one of the most closely observed water bodies in the world, we have none of these things.

Monster-watching is now organized with almost military thoroughness (with cameras, sonar sets, and submarines); the loch is on the route of thousands of press-conditioned tourists; it is also part of the Caledonian canal system; fishing boats, small naval vessels, and pleasure craft pass through constantly. Apart from two bays, it is nowhere wider than 2 miles. And yet, to the true believer (professional or lay), the anticipated probability of finding something does not appear to decrease with the negative results of each passing year of organized observation. There al-

ways remains some residual unexplained point or observation to sustain the faith. Is there an analogy here with ESP? I enjoy the fun, but must relegate it for the time being to parascience.

At this point in the argument, stuffy zoologists who voice the kind of pompous biases I have expressed are confronted with the miracle of the coelacanth. But the important point about the coelacanth is that the hunt began after Miss Courtnay-Latimer had seen an unusual *specimen* and had shown it to a qualified ichthyologist. No such specimen or even part of one do we have from Loch Ness.

In the complete absence, over centuries, of tangible zoological evidence, we are left with some poorly focused unscaled photographs, verbal accounts of observers given in good faith, and some unexplained sonar echoes (obtained by highly competent teams, e.g. Braithwaite 1968). On the latter point I would remark that, with its steep rocky sides, Loch Ness is a reverberant basin; and I know from personal experience that lateral echoes are easy to pick up on the side-lobes of an echo-sounder's beam. That is the most likely explanation of press pictures of *N* obtained from fishing boat echo-sounders (e.g. *Daily Herald*, London, 7 December 1954), but does not explain Braithwaite's (and other?, *Time*, 20 November 1972) observations. For those, a possibility worth looking into depends on the acoustic-reflective properties of internal waves or regions of shear instability, in particular the steep-fronted internal surges, associated in Loch Ness with short internal waves and described by Thorpe et al. (1972). It is well known that internal density gradients in water (e.g. thermoclines) can be picked up on echo-sounders (Hollan 1966); and the steep and corrugated "fronts" of the Loch Ness surge is a possible, although somewhat far-fetched, explanation of the anomalous echoes. If the even less likely explanation —existence of *N*—turns out to be the correct one, here is one skeptic who will be delighted to be confounded. But some fun would go out of life if the myth of fourteen centuries (from St. Columba to *Time*) were finally laid to rest.

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REFERENCES

BRAITHWAITE, H. 1968. Sonar picks up stirrings in Loch Ness. New Sci. (London), 19 December 1968.

BURTON, M. 1961. The elusive monster. Hart-Davis.

HOLLAN, E. 1966. Das Spektrum der internen Bewegungsvorgänge der westichen Ostsee im Periodenbereich von 0.3 bis 60 Minuten. Deut. Hydrogr. Z. **19**: 285–298.

SCHEIDER, W., AND P. WALLIS. 1973. An alternate method of calculating the population density of monsters in Loch Ness. Limnol. Oceanogr. **18**: 343.

SHELDON, R. W., AND S. R. KERR. 1972. The population density of monsters in Loch Ness. Limnol. Oceanogr. **17**: 796–798.

THORPE, S. A., A. HALL, AND I. CROFTS. 1972. The internal surge in Loch Ness. Nature **237**: 96–98.

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The Loch Ness monster: Reply to comments of C. H. Mortimer

There is no reason why science cannot be both a serious occupation and also fun to do. The note on the Loch Ness monster was written for fun. We enjoyed writing it and we hope that people enjoyed reading it. But it was never intended to be, nor is it, science fiction. Within the limitations we stated, our reasoning was serious and moderately rigorous. The primary value of the contribution by Scheider and Wallis (1973), in our view, is that it nicely underscores the point that a real question